NOTE XIV.

REVISION OF THE FOSSIL ECHINI FROM THE TERTIARY STRATA OF JAVA.

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In the year 1854 J. A. Herklots published a description of the fossil Echini, which had been found by Junghuhn in the tertiary strata of Java, in the fourth part of a publication, entitled «Fossiles de Java." I have been occupied in working out the other groups of animals from these deposits, which by the death of Herklots was left unachieved. The results of my investigations have been embodied in the work entitled »Die Tertiärschichten auf Java", the palaeontological part of which has appeared a short time ago. I succeeded in demonstrating, that a considerable percentage of these fossils are yet represented in the recent fauna of the Indian Ocean, and for this reason I was astonished to find, that all the Echini, with only a single exception, were described by Herklots as new species. This induced me to undertake a revision of these species, which has indeed led me to results entirely different from his. Not only a large number, but by far the majority of all the wellpreserved individuals could be identified with species, which are still living in the Indian Ocean.

As the fossils have been fully described by Herklots in the publication mentioned above, a short enumeration of my diagnoses may suffice, with the exception of two fossils, which, curiously enough, Herklots has never mentioned. I may here remark, that Herklots' figures are often incorrect, showing either more or less than the fossils themselves, a circumstance which I am obliged to mention, in order to explain the discrepancies between those figures and the diagnoses, which I am about to give.

1. ***Phyllacanthus baculosa Ag.*** I cannot regard the fossil, which Herklots described as *Cidaris rugata* (l. c. pag. 3), although it is in an imperfect state of preservation, as distinct from this species. It is very probable, if not certain, that the spine figured Pl. I, Fig. 2 also belongs to the same species.

Cidaris halaensis d'Arch et Haime (Descript. des anim. foss. de l'Inde pag. 196, tab. 13, fig. 2) is indoubtedly closely allied to *Ph. baculosa Ag.*, although the minute miliaries, which cover the median interambulacral space, are less densely arranged, as far as the figure at least permits to judge. Still it may prove to be identical on comparison with the typical specimen.

2. ***Temnopleurus toreumaticus Ag.*** Herklots has established two species, *T. areolatus* and *T. caelatus* (l. c. pag. 4 a 5), which differ from the normal *T. toreumaticus* in some few respects. In *T. areolatus* the horizontal pits between the interambulacral plates of the same vertical row penetrate for a short distance into the contiguous plates of the adjacent row, causing the internal borders of these to take a forked appearance (Comp. Herkl. l. c. Pl. I. Fig. 5b). *T. caelatus* is distinguished from *T. toreumaticus* by having smaller primary tubercles. Now I have been able to examine a series of recent specimens of the last named species from Japan, in which the forked appearance of the internal borders of the plates is either absent or hardly conspicuous or well marked, and which show at the same time rows of smaller primary tubercles. I have no reason to doubt the

identity of these specimens with *T. toreumaticus*, the more so as the abactinal system, which is very well preserved in some of these japanese specimens, exactly corresponds to that of *T. toreumaticus*. For this reason I feel justified in regarding *T. areolatus* and *T. caelatus* as varieties of *T. toreumaticus*.

3. ***Pleurechinus javanus nov. spec.*** The test of this species is high, spherico-pentagonal. The ambulacral areas have more than half the width of the interambulacral areas. The poriferous zones are narrow, straight, with simple, unigeminal pores; three pairs of pores belong to one primary plate. There are deep pits along the horizontal sutures of all coronal plates. Vertical ridges unite the plates of the same row, bridging these intervals. As the plates gradually acquire greater width towards the middle of the test, the number of the vertical connecting ridges increases from one to three, five and even seven; the middle one (the primary ridge, corresponding in position to a primary tubercle) being always the strongest. When there are seven, the two widest apart are exceedingly small. On the ambulacral areas the connection of the plates is brought about, firstly by primary ridges corresponding as before to primary tubercles and situated exteriorly in the immediate neighbourhoud of the poriferous zone, secondly by secondary ridges. Of the latter there are never more than two, in accordance with the lesser width of the ambulacral areas. As all the connecting ridges of the coronal plates have the same direction, they give rise to a graceful system of parallel stripes, which cover the whole test.

In addition to the primary tubercles (situated on the middle of the plates belonging to the interambulacral areas and on the inner border of the poriferous zone on those plates, which belong to the ambulacral areas) we find on all the plates tubercles of the 2nd and 3d order, which however do not correspond to the secondary ridges. The actinal and abactinal systems are subcircular.

The dimensions of the largest of eight specimens examined are:

height = 17 mm.
diameter of basis = 24 mm.
» » abactinal system = 6 mm.
» » actinal system = 8 mm.

This fossil is so entirely different from the only recent representative of this interesting genus, *P. bothryoïdes Ag.* (from the Indian Ocean), that an enumeration of the specific differences may appear superfluous. On the other hand *Temnopleurus tuberculosus*, a *Pleurechinus* from the tertiary strata of India, which was described under that name by d'Archiac and Haime, is very nearly related to our javanese form. However in this indian fossil the number of the vertical ridges, which connect the widest plates of the interambulacral areas, is less, the rows of primary tubercles do not occupy the middle of these plates, whereas the number of smaller tubercles is at the same time diminished.

4. ***Stomopneustes variolaris Ag.*** It is impossible to distinguish *Heliocidaris variolosa Herkl.* (l. c. pag 5, tab. I, fig. 4) from this species, although Herklots pretends, that the javanese fossil differs: »par les rangées secondaires de gros tubercules sur les aires ambulacraires moins développées et par la forme conique à base parfaitement plane." A comparison of a series of recent specimens from this species, which is so common in the Indian Ocean and on the coast of Java, shows, that there is a considerable range, between which this species may vary, not only with respect to the development of the tubercles but especially to the form of the test. The basis is flattened in a varying degree, and I feel obliged to identify this fossil, however strong it may be flattened, with *S. variolaris Ag.* The axis of the test has the same obliquity as in the recent specimens.

5. ***Laganum multiforme nov. spec.*** The outline of the test is very variable, distinctly pentagonal with rounded angles or even nearly elliptical with hardly any reminescence of the polygonal form. The greatest diameter is in a line with the anterior extremities of the an-

terior pair of ambulacra. The test is very much flattened, its edge swollen; a strongly marked depression surrounds the petals. They are long and of equal length, lanceolate, nearly closed at the extremity. The pores, connected by distinct grooves, are closely packed together; there are five of them in a millim. The abactinal system is small, five indistinct ridges radiate from hence along the middle ambulacral area. The basis is flattened or indistinctely concave. The mouth is small and subcircular; so is the anus, although sometimes inconspicuously elongated in the direction of the longitudinal axis of the test; its distance from the border being about two or three times its diameter. The ambulacral furrows are indistinctly developed and extend about half the distance between the mouth and the angles of the test. The peristomal star is still more indistinct, sometimes even hardly visible. The primary tubercles are equal in size on the superior and inferior surface of the test and measure about $\frac{1}{3}$ of a mm.; on the inferior surface they are at a greater distance from each other, and on the border closely set. There are constantly fine granules between them. Genital openings as in *L. depressum*.

The pentagonal forms of this fossil are closely similiar to the last named species, they may however be immediately recognized by their larger tubercles and by the stronger depression surrounding the petals. They may further be distinguished by the less developed ambulacral furrows and peristomal star, although the same may be the case in certain varieties of *L. depressum*, which thereby show a greater similiarity with *L. multiforme*. Moreover in those specimens, where the anus is elliptical, the fact that its longest diameter is parallel to the longitudinal axis of the test and finally the circumstance, that the fossil does not attain the dimensions of the recent species, may serve to distinguish them from specimens of *L. depressum*. The dimensions of the largest specimen are:

length = 29 mm.
greatest width = 26 mm.

smallest width on the posterior border = 20 mm.
height = 4 mm.

6. ***Peronella decagonalis Ag.*** is indoubtedly identical with *Scutella decagona Herkl.* (l. c. pag. 9. tab. I, fig 6). The individual figured by Herklots appears to be distinguished from this recent species by the lesser elevation of the middle part of the superior surface; however another somewhat smaller specimen, measuring 33 mm. entirely corresponds to the typical *P. decagonalis* even in this respect, and so this deviation must be regarded as no more than a variety. The lanceolate shape of the petals is indeed different from the straightbordered petals of the large individuals of *P. decagonalis*; this however is a consequence of the different age of the specimens.

I can no more separate *L. angulosum Herkl.* (l. c. pag. 8, tab. 2, fig. 4) from *P. decagonalis* and likewise I take *L. rotundum Herkl.* to be the same species, as far as least as the bad condition of this last named fossil permits to judge.

L. tenuatum Herkl. (l. c. pag. 9, tab. I, fig. 7) is *perhaps* distinct from the above mentioned forms by its concave inferior surface. Only it is too insufficiently preserved to allow of a definite judgment.

7. ***Peronella orbicularis Ag.***, = *Laganum orbiculare Ag.* (Herkl. l. c. pag. 7, tab. 2, fig. 3), was rightly recognized by Herklots, as far as I can see; however Agassiz puts forward the possibility of this species being the young stage of *P. decagonalis Ag.* (Revision of the Echini Part. III, pag. 521). I believe this to be highly probable, especially on comparison of the young specimen, named by Herklots *L. angulosum*, with *L. orbiculare.* It is only the shape of the border, by which in this case a distinction might be effectuated, and as the different *Laganum*-species vary so considerably in this respect, it may not serve to distinguish species. Nevertheless I make separate mention of *P. orbicularis* and *P. decagonalis* because the superior surface of the fossil *P. orbicularis* is

in a too imperfect state of preservation to permit my forming a definite judgment on the point in question, as I am moreover not possessed of sufficient recent material for comparison.

8. ***Clypeaster humilis Ag.*** is represented by specimens, partly beautifully preserved, amongst the javanese fossils. It was described by Herklots as *Cl. latus* (l. c. pag. 6, tab. 2, fig. 1).

Echinanthus profundus d'Arch et Haime (Description des anim. foss. de l'Inde pag. 207) is indoubtedly identical with this species, as the character, by which they are said to be distinguished: »ses bords plus minces et ses pétals plus arrondis inférieurement et complétement fermés" are easily found as varieties among the specimens of *Cl. humilis*.

9. ***Echinanthus testudinarius Gray.*** The fossil which Herklots described as *Clypeaster tumescens* (l.c.pag.7, tab. 2, fig. 2) does not show the slightest difference, by which it may be distinguished from this recent species inhabiting the Indian Ocean, and of which the Leyden Museum also possesses specimens from Timor. Nevertheless the confirmation of my diagnosis by the aid of better preserved specimens seems desirable.

According to Duncan (Quart. Journ. Geolog. Soc. London 1877 XXXIII p. 46 u. 65) this fossil is also found in the tertiary strata of Australia, which is however denied by Mc. Coy, who describes the Australian fossil as *Cl. gippslandicus* (Prodromus of the Palaeontology of Victoria Dec. VI. tab. LIX).

10. ***Echinolampas oviformis Ag.*** Probably identical with *E. subangulata Herkl.* (l. c. pag. 10, tab. 3, fig. 4). The state of preservation, however, does not allow of a definite judgment, nor whether *Nucleolites minutus Herkl.* (l. c. pag. 10, tab. 5, fig. 8) must be regarded as the young stage of this species. The name *Nucleolites* can not be retained for this fossil.

d'Archiac et Haime have described from the tertiary strata of India *E. Iacquemonti*, which is said to be distin-

guished from *E. orientalis* and *E. oviformis* (which are synonymous) by their longer and less closed petals (Anim. foss. de l'Inde pag. 212). I have examined specimens of *E. oviformis Ag.*, which so closely agree with the figure given by d'Archiac and Haime (l. c. tab. 14, fig. 5), that I have no doubt *E. Iacquemonti* must be regarded as synonymous with *E. oviformis*.

11. ***Brissus declivis Herkl.*** is nearly allied to *B. carinatus Gray*.

12. ***Brissopsis luzonica Ag.*** *Brissopsis latior Herkl.* is identical with this species. *Verbeekia dubia v. Fritsch* (Eocänformation von Borneo, copie in »Jaarboek voor Mijnwezen" 1879 I, pag. 137, tab. 11, fig. 4) also appears to be synonymous as far at least as the incomplete preservation of the Bornean fossil permits to judge. Zittel (Handbuch der Palaeontologie pag. 541) had already united *Verbeekia* with *Brissopsis*.

13. ***Schizaster subrhomboidalis Herkl.*** is very closely allied to *Sch. ventricosus Gray*, which has been also found in a fossil state in Australia (Duncan, Quart. Journ. Geol. Soc. 1877, XXXIII, pag. 61 u. 68). A real difference between *S. ventricosus* and the javanese fossil is to be found in the outline of the last named species, which is more or less pentagonal in consequence of the stronger flattening posteriorly and the considerable widening of the middle of the test. Moreover the petals are more divergent in *S. subrhomboidalis*. The *fasciola peripetala* is widened out towards the extremity of the petals, especially anteriorly, as in *S. ventricosus*.

14. ***Pericosmus granulosus Herkl.*** = *P. rotundatus Herkl.* = *P. planulatus Herkl.* = *P. distinctus Herkl.* They do not show any differences, which might not be explained by the different state of preservation, of which Herklots has not taken sufficient note.

15. ***Pericosmus asperulatus Herkl.*** may be distinguished from the preceding species by a small difference in the course of the *fasciola peripetala*, which encircles the hinder petals not in a angularly bent, but in

a curved course. However the specific value is subject to some doubt, as the development of the *fasciolae* may vary to a certain, although rather limited extent in the same species.

16. ***Pericosmus altus Herkl.***

17. ***Breynia magna Herkl. spec.*** was described by Herklots as *Eupatagus magnus* (l. c. pag. 13, tab. 2, fig. 7). It is closely allied to *B. Australasia Gray*; it differs however from the recent specimens, which I have been able to examine, by the more strongly bent border of the test and the less conspicuous development of the secondary tubercles on the marginal superior surface. The course of the *fasciola peripetala* and of the *fasciola interna* is very indistinct, appears however to agree with that of *B. Australasia*. This justifies a separation from *B. carinata d'Arch et Haime* (Anim. foss. de l'Inde pag. 216, tab. 15, fig. 4). However, the fossil figured by Medlicott and Blanford as *B. carinata d'Arch et Haime* (Geology of India tab. 16, fig. 9) differs markedly from that, which d'Archiac and Haime have described under that name, and shows great affinity to the javanese fossil. For the present I do not feel justified to regard them as identical.

18. ***Maretia planulata Gray.*** *Spatangus praelongus Herkl.* and *S. affinis Herkl.* are identical with this species and could never be brought under the genus *Spatangus Klein*, as there are no primary tubercles on the posterior intrambulacral area. The distinct *fasciola subanalis*, which was neither noticed nor figured by Herklots, does not allow of an identification with *Hemipatagus Desor*, so that the javanese fossil can never be identical with *H. formosus Zittel* (Comp. Novara Expedition Palaeontologie von Neu-Seeland pag. 63). The state of preservation of the fossils is very sufficient and leaves no doubt as to their identity with *M. planulata Gray*.

19. ***Maretia? pulchella Herkl. spec.*** It was described by Herklots as a *Spatangus*, but must be separated from this genus for the same reasons mentioned above. Still

their identity with *Maretia* is subject to some doubt by the imperfect state of preservation. There is a distinct *fasciola subanalis*.

Those fossils described by Herklots, which are not mentioned above, are in such a bad state of preservation, that not even a generical diagnosis, much less a specific determination is possible, and so I feel obliged to leave them unnoticed, as they have no further value for the tertiary fauna of Java and its connection with the recent fauna of the Indian Ocean.

Our present knowledge of the fossil Echini of Java may be shown by Table I.

This table clearly shows, that, also with respect to the Echini, the recent fauna of the Indian Ocean may be traced up to the tertiary strata of Java [I have elsewhere attempted to prove this for Mollusca, Crustacea and Corals]. And further, that these tertiary strata, the age of which I am not yet able to fix with certainty, contain no fossils, which have also been found in extratropical tertiary deposits, so that even in the tertiary period the separation of the tropical oceanic fauna appears to have been quite as distinct as we find it in the present day.

In comparison to the other classes of invertebrate animals the percentage of the Echini found simultaneously in the tertiary strata of Java and yet living in the seas of these regions is considerable (See Table II).

NB. The localities indicated with [ ] in the fourth column of Table I are the same for those fossils, which follow in the fifth column among the nearly allied forms; as for the present it is not possible to decide, wether they are actually identical with the corresponding javanese fossils.

TABLE I.

Names.	Still living.	Allied recent species	Fossil in:	Allied fossil species.
1. Phyllacanthus baculosa Ag.	+	—	[India?]	Cid. halaensis d'Arch Haime. (India).
2. Temnopleurus toreumaticus Ag	+	—	—	—
3. Pleurechinus javanus Mart.	—	—	—	Temnopleurus (Pleurechinus) tuberculosus d'Arch Haime (India).
4. Stomopneustes variolaris Ag.	+	—	—	—
5. Laganum multiforme Mart.	—	L. depressum Less.	—	—
6. Peronella decagonalis Ag.	+	—	—	—
7. Peronella orbicularis Ag.	+	—	—	—
8. Clypeaster humilis Ag.	+	—	India.	—
9. Echinanthus testudinarius Gray	+	—	[Australia?]	Clyp. gippslandicus Mc. Coy. (Australia).
10. Echinolampas oviformis Ag?	+	—	India.	E. dispar v. Fritsch (Borneo).
11. Brissus declivis Herkl.	—	B. carinatus Gray.	—	—
12. Brissopsis luzonica Ag.	+	—	Borneo.	—
13. Schizaster subrhomboidalis Herkl.	—	S. ventricosus Gray.	—	S. ventricosus Gray. (Australia).
14. Pericosmus granulosus Herkl.	—	—	—	—
15. Pericosmus asperulatus Herkl.	—	—	—	—
16. Pericosmus altus Herkl.	—	—	—	—
17. Breynia magna Mart.	—	B. Australasia Gray.	[India?]	B. carinata d'Arch Haime. (India).
18. Maretia planulata Gray	+	—	—	—
19. Maretia? pulchella Mart.	—	—	—	—

TABLE II.

Summary of the number of fossil species found in the tertiary strata of Java.	Number of recent species identical with fossil ones.	Percentage.
Cephalopoda. 1	. . . . 0	 0
Gastropoda 160	. . . . 47	 29
Lamellibranchiata 74	. . . . 28	 38
Brachiopoda. 1	. . . . 0	 0
Crustacea 9	. . . . 6	 67
Echinoidea 19	. . . . 10	 53
Corallia 36	. . . . 4	 11
Foraminifera . . . . . 6 (Nummulinidae)	. . . . 0	 0
Total 306	. . . . 95	 31